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Title: Building a CO2 Economy in the Four Corners Region

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Building a CO_2 Economy in the Four Corners Region

Background

This project will assess options in the Four Corners region relative to developing a CO_2-based economy, considering both CO_2 supply (via capture) and CO_2 demand (utilization and storage). The assessment will consider a spectrum of opportunities at various stages of technology readiness, including their magnitude and regional distribution. An additional component (via a collaboration TBD) will evaluate the regional implications relative to economy and job growth.

The recent assessment by the Intergovernmental Panel on Climate Change emphasizes the importance of carbon dioxide removal (CDR) as part of the portfolio of options needed to reduce atmospheric emissions of greenhouse gases,[1] spanning from afforestation to engineered removal of atmospheric CO_2. While the former plays an important role, the latter is needed in most scenarios that meet reduction goals. The scale of this challenge necessitates developing a CO_2-based economy capable of removing large volumes of CO_2 (ultimately from the atmosphere), handling large volumes of CO_2 (e.g., as a gas or supercritical fluid), and disposing/utilizing large volumes (e.g., in long-term storage or in sustainable uses). A CO_2-based economy recognizes the need to balance supply and demand; hence, increasing demand increases supply.

The underlying driver for this study is:

> *The Four Corners region offers an opportunity to develop and demonstrate a CO_2 based economy, using a potential large-scale project on post-combustion capture of CO_2 at the San Juan Generating Station to catalyze the development, testing, and demonstration of a range of capture and utilization strategies needed for a CO_2-based economy.*

The Four Corners region mirrors many other communities that have been historically developed around a fossil-fuel economy. Development of a CO_2-based economy in such communities could enable the use of existing infrastructure and resources to create new employment and manufacturing opportunities around CDR. A strategy developed for the Four Corners region could be adapted to the unique aspects of other communities.

CDR requires both capture and storage/use. This assessment will evaluate a spectrum of options for CDR broadly in the Four Corners region, ranging both in scale and in technology readiness:

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[1] IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. P.rtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. P.an, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

- The proposed post-combustion capture project at SJGS provides one end of the spectrum: large scale and high TRL, with amine-based capture from a concentrated point source and selling of CO_2 for enhanced oil recovery in Texas.
- Capture at other regional point sources and regional utilization of CO_2 in a range of high TRL applications represents a mid-point in the spectrum.
- Capture from the atmosphere (e.g., bioenergy capture or direct-air capture) and regional utilization of CO_2 with renewable hydrogen and/or stranded/fugitive methane represents a longer-term end of the spectrum.

The spectrum of options can lead to a regional strategy to develop and implement a CO_2 based economy beginning with near term high TRL options and leading to a portfolio of longer-term options with high potential.

Focus of Assessment

<u>Topics for consideration in the assessment include:</u>

CAPTURE:

- Other point sources of CO_2 in the region (coal, NG, cement, etc.)—distribution, magnitude, readiness and economics of capture technology
- Bioenergy coupled with carbon capture and storage (BECCS), including potential for co-firing of biomass at SJGS
- Methane as a commodity to stimulate capture of regional fugitive emissions
- Direct air capture—lower TRL but research, testing, and demonstration could be piggy backed with the post-combustion operations

USE/STORAGE:

- Regional opportunities for CO_2-EOR, enhanced coal-bed methane, etc.—distribution, magnitude, potential to reduce fugitive methane emissions
- Regional opportunities for geologic storage, including stacked storage—in partnership with CUSP
- Use of CO_2 in recovery of geothermal energy—includes both CO_2 as a working fluid in hot-dry rock and co-injection with aqueous working fluid
- CO_2 mineralization in conjunction with new-materials manufacturing and/or critical material recovery—includes an assessment of regional coal-related wastes such as coal to products with manufacturing at source
- Biomass production with captured CO_2—greenhouses, stacked greenhouses (aquaculture), algae; including assessment of synergies with power-purchase agreements to stabilize power balance on grid to facilitate incorporation of renewables
- CO_2 to fuels/feedstocks using renewable hydrogen and/or stranded/fugitive methane
- CO_2 to new, readily recyclable polymer-based materials

REGIONAL INFRASTRUCTURE:

- Optimal pipeline networks to stimulate CO2 economy

ASSOCIATED OPPORTUNITIES:

- Recovery of critical materials (fly ash, other coal-related materials, mineralization feedstock)—including CO_2 as a recovery solvent
- Brine desalination (in association with CO_2 storage; perhaps involving CO_2 to form clathrates)

Timeline/Deliverables

This assessment will extend for ~6 months.

An interim report is anticipated for delivery in early summer 2020, with the initial assessment of sources and uses within the region. This report will consider the likely time evolution of these opportunities based on TRL.

A final report will be delivered before the end of FY20 (September 2020). This final report will expand on the assessment of sources and uses, looking at infrastructure that could enable development as well as potential regional economic impacts.

Building a CO_2 Economy in the Four Corners Region

Capturing (and handling) CO_2 ⟷ **Utilizing (and storing) CO_2**

(Supply) *(Demand)*

- Limiting demand can limit supply
  (lesson from early integrated projects)
- Increasing demand can incentivize supply, and vice versa
  (corollary implication)
- Fostering an "economy"—i.e., a portfolio of supply/demand—can lead to new jobs, growth, etc.

Phase I Assessment:
Analysis of options, strategy in space/time

Capturing (and handling) CO_2
- Ultimately from the atmosphere

Utilizing (and storing) CO_2
- Sustainable markets

Post-Combustion Capture
- Regional point source opportunities (size & distribution; feasibility of capture technology)
- Direct air capture (plus renewable source)
- BECCS (including at SJGS?)
- Other bio-capture mechanism?

Storage Infrastructure
- CO_2-EOR, storage; economics (e.g., 45Q, size of prize), other subsurface uses (geothermal, O/G)
- Enabling pipeline/transport infrastructure

Use/Re-use
- Stacked greenhouses
- Fuels, chemicals, plastics, etc.
- Enabling hydrogen storage
- Potential role of fugitive methane

Water Management
- Produced brines (desal, water as a product/resource, etc.)

Rare-earth Recovery
- Coal-related materials, ultramafics used for mineralization, produced waters, etc.

Overall Focus
- Phase I assessment
- Regional perspective
  - Unique sources; unique options for storage/use; geographic factors
- Potential regional impact
  - Size/scale of options; economics; jobs; etc.

Our Team

Capturing (and handling) CO_2 ⟷ Utilizing (and storing) CO_2

(Supply)

- **Chris Russell, Joel Kress**
  (CCSI)
- **Rajinder Singh**
  (capture membranes; water desal)
- **Manvendra Dubey**
  (fugitive methane; LDRD)

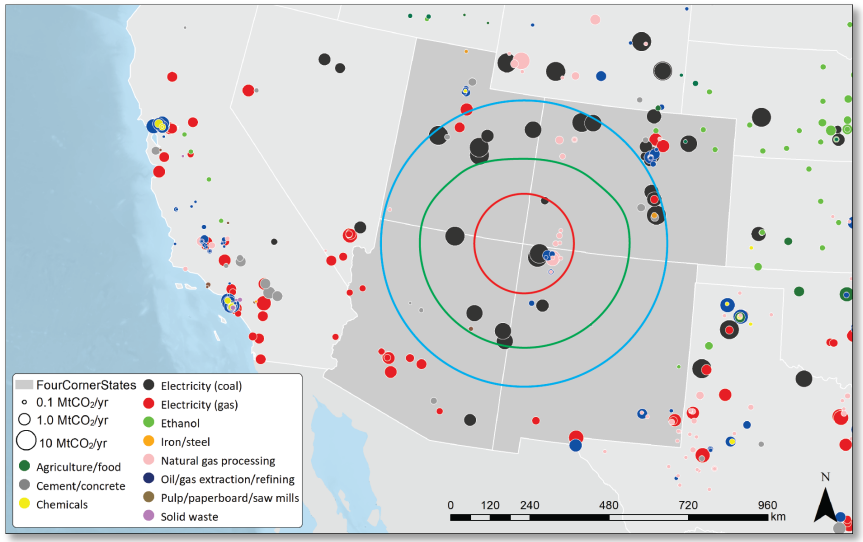
- **Richard Middleton**
  (SimCCS, CarbonSAFE, CUSP)
- **Ross Beattie, Dom Peterson, Jackie Kiplinger, Hakim Boukhalfa, Artas Migdissov**
  (REE/FE, LDRD, Critical Materials)
- **Robert Currier**
  (LDRD, water desal)
- **George Guthrie**

(Demand)

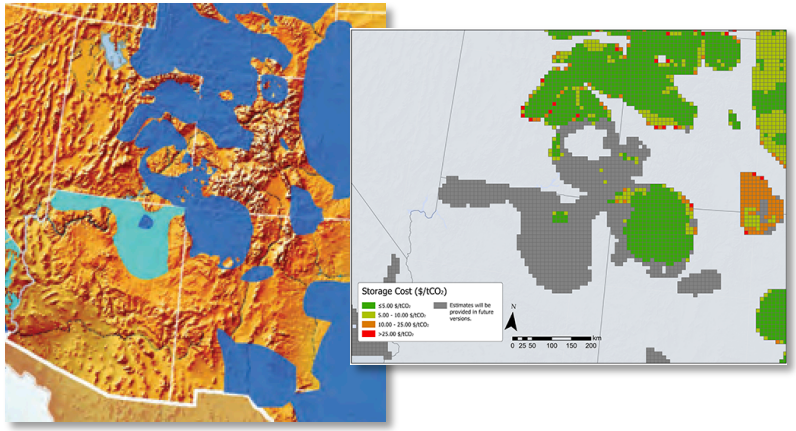
- **Bailian Chen, Rajesh Pawar, Hari Viswanathan**
  (NRAP; SWP, CUSP, CarbonSAFE)
- **Maruti Mudunuru**
  (CO_2 + geothermal)
- **Babs Marrone**
  (BETO, LDRD; algae, bio, plastics)
- **John Gordon**
  (DOE-SC; fuels, feedstocks, plastics)
- **Bill Carey**
  (CO_2 Mineralization)

The Region

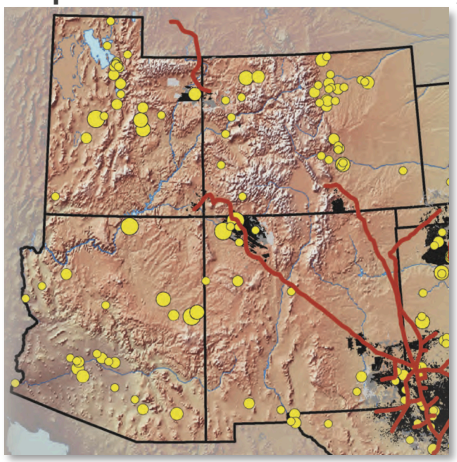
Sources



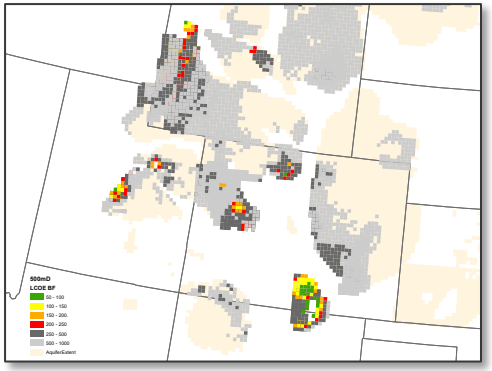
Saline Formations



Pipelines/Natural CO_2



Geothermal



Mineralization